The Absorber Cooling RAW System.

General:

This system provides cooling to the NuMI Absorber (Beam Dump), which is located in the NuMI Absorber Cavern at the downstream end of the decay pipe, approximately 300 feet below grade. The RAW loop portion of the system is in the absorber access tunnel near the end of the Decay Pipe. The pump, heat exchanger, DI bottle and instrumentation will be located on a skid and that skid will be located in the absorber access tunnel in a relatively low radiation area. The RAW loop portion of the system rejects its heat to an Intermediate Water System, which in turn rejects its heat to a pond water system at the MINOS service building. Control of the intermediate system is within the scope of the NuMI Water Systems Controls but the pond water system is not. Except as noted, the Absorber RAW system is in the scope of WBS 1.1.7

Heat Loads:

This is a simple RAW system with only one heat load. Heating is due only to absorbed beam. Steady state heat load with the beam hitting the target is approximately 60 to 70 kW. The heat load could be as high as 400 kW if beam misses the production target. Heat is exchanged to a plate/frame heat exchanger that is connected to a MINOS service building intermediate loop. Heat is ultimately exchanged to an outside pond near the MINOS service building. Temperature of the process water is not regulated. The heat exchanger is designed to exchange 200 kW at the design temperature differences. Higher heat loads can be transferred, but result in increased temperature of the absorber water.

Activation:

The water in this system will become activated. A pump (and standby) drives the system and there is a DI bottle to take out ions created by the radiation. The tritium concentration in the water as a function of running time has not been calculated, therefore the level of activation of the water is not known. Access to this skid based system is difficult at best and likely prohibited during NuMI operation.

Piping:

Piping run between the absorber and the RAW pump and heat exchanger skid is nominally sized at 3 inch schedule 10S stainless steel welded piping, specification A312 Type 304. It is estimated that there is about 100 feet of piping one way between the skid and the absorber. Maximum anticipated operating pressure of the system is approximately 50 psig. Piping will be installed in accordance with ASME B31.3 piping code and will be subjected to non-destructive examination (radiography). Maximum allowable pressure rating for this piping at the design temperatures of less than 200 degree Fahrenheit is 235 psig. The aluminum to stainless steel transition is considered part of the absorber and not of the water system.

Alternatively, the piping between the absorber and the RAW skid could be built from aluminum. In this case, the aluminum pipe would be schedule 40 and the stainless to aluminum transitions would be located at the pump skid. Aluminum pump casings are not readily available nor are aluminum heat exchangers. Such a scheme would move the aluminum to steel transition away from the absorber and to the lower radiation area near the skid, but would add cost to the RAW system. Such costs are not budgeted for in WBS 1.1.7.

Secondary Containment:

Secondary containment for the piping has not been provided for in the cost estimate. Risks associated with piping designed and installed in accordance with ASME B31.3 and operated at pressures well below the maximum allowable pressure and with relatively small temperature changes does not pose a risk of a catastrophic failure.

Secondary containment under the pumps and equipment on the pump skid is provided for in the cost estimate. The reason the skids receive secondary containment is because of the relatively higher failure rate of the pump seals (pump seals are a wear item subject to wearing out) and the many instrumentation connections on the pump skid. The secondary containment is sized to contain the volume difference in the pump suction tank between the maximum level and the low level, which triggers the pump to shutdown. The secondary containment is not sized to contain 100% of the volume of the total system.

Secondary containment for water, which may be leaked from the absorber core, is within the scope of WBS 1.1.4

Materials of Construction:

Materials of construction for the water system will be limited to only aluminum in the absorber core, austenitic stainless steel for the heat exchanger, and austenitic stainless steel for the pumps. All instrumentation will have all stainless steel wetted parts. No copper, brass, or copper bearing materials will be used. This statement means that the normal brass quick disconnects on the DI bottles will need to be replaced with stainless steel connections each time a bottle is changed.

Controls:

Remote operation and monitoring is clearly desired. A hard-wired system seems appropriate to the control of this system. It is assumed that ACNET controls infrastructure will be available in the near vicinity given the proximity of muon monitors.

Absorber Cooling RAW System Interlocks and Instrumentation List:

For this water system, the following summary lists the interlocks, alarms, permits, analog variables, ON-OFF signals to and from ACNET, and finally the local instrumentation.

Pump Motor Interlocks:

This water system has two pumps, one designed to run and a second in hot stand-by. Each pump is protected by a series of interlocks. These interlocks are typically dry contact switches that are wired so that the contact is closed when the parameter is such that the pump can safely operate. These pump interlocks may be implemented in hard wired relay logic (ladder logic) or implemented in a Programmable Logic Controller (PLC). The decision as to which method to use to implement this logic will be made after the costs (including hardware, labor, design effort and installation effort) are understood. The pumps will be prevented from being turned on or will be shut down if running for the following conditions:

Absorber RAW Pumps:
Contactor – 3 phase rotation
Over-current
Motor Internal Over-temperature Switch
(Wired Normally Closed)
Absorber RAW Expansion Tank Liquid Level Low Low

Absorber Intermediate Loop Pumps:
Contactor – 3 phase rotation
Over-current
Motor Internal Over-temperature Switch
(Wired Normally Closed)
Absorber Intermediate Loop Expansion Tank Liquid Level Low Low

Analog Variables to ACNET

The Absorber RAW system will have a number of instruments, with output analog variables. The analog variables are to be displayed on an ACNET parameter page. Programming cost for a customized application program is not included in the scope of WBS 1.1.7. Typically, these variables include water system pressures, temperatures, flow rates, expansion tank liquid levels, and resistivity. Trending of these variables is desirable. These signals may be chosen to be 4-20 ma signals or 0 to 10 VDC signals. The decision as to whether these analog signals are fed directly into a MADC or are fed into a PLC and then passed as digitized data into ACNET remains to be decided. The analog variables from Absorber RAW system instrumentation to ACNET are:

Absorber RAW Pump Discharge Pressure (Supply Pressure)
Absorber RAW Return Pressure
Absorber RAW Pump Suction Pressure
Absorber RAW Water Supply Temperature
Absorber RAW Water Return Temperature
Absorber RAW Water Expansion Tank Liquid Level
Absorber RAW Resistivity out of the DI Bottle (4-20 ma Signal)
Absorber Intermediate Loop Supply Temperature

Alarms to ACNET

From the set of analog variables, there will be alarms for conditions where the analog variable either exceeds or is less than a given value. The intent is that when the variable exceeds (or falls under) a given value, an alarm will be displayed on the alarms display in the main control room. These alarms will be generated in ACNET in comparing the value of the analog variables to predetermined 'limits':

Absorber RAW Expansion Tank Liquid Level Low
Absorber RAW Expansion Tank Liquid Level High
Absorber RAW Water Supply Temperature High (alarm if value > 105 Degrees F.)
Absorber RAW Water Return Temperature High (alarm if value > 125 Degrees F.)
Absorber Intermediate Expansion Tank Liquid Level Low
Absorber Intermediate Expansion Tank Liquid Level High
Absorber Intermediate Water Supply Temperature High (alarm if value > 95 Degrees F)

ON-OFF Signals to ACNET

Instruments on this system will generate digital status for reading by ACNET. These signals will be dry contacts opening or closing or login levels to indicate the status of a particular item. For example, the intent is to monitor current switches on the pump motors and to indicate on an ACNET console a positive indication based on feedback that a particular pump is drawing current (on) or not drawings current (off). The ON-OFF signals to ACNET are:

Absorber RAW Pump Current Switches (2)
Absorber Intermediate Pump Current Switches (2)

ON-OFF Signals from ACNET

This RAW system will receive one set of digital commands from ACNET. These signals will be used to start or stop pumps based on an operator's command at the ACNET console:

Absorber RAW Pump Remote Start and Stop Switches

Inputs to Beam Permit

The instrumentation on this system will generate 'permits'. These permits will be for 'beam permits' or 'power supply permits' or both. The intent of these permits is to generate a single signal that indicates satisfactory operation of the water system. Should the parameters of the water system indicate that the system is not operating satisfactory, the permit signal will be removed. Pump motor interlocks are discussed in the above paragraph on the pumps and are not considered 'permits'. The permit inputs are:

Absorber RAW Return Water Temperature Not High (permit if value < 130 Degrees F)
Absorber RAW Pump Differential Pressure Not Low
Absorber RAW Pump Differential Pressure Not High
Either Absorber RAW Pump Drawing Current
Absorber RAW Expansion Tank Level not Low Low

Either Absorber Intermediate Pump Drawing Current
Absorber Intermediate Expansion Tank Level not Low Low

Local Instrumentation (Gauges w/o wires)

Lastly, each system has additional local instrumentation, which is not connected to the control system. This instrumentation is typically comprised of pressure gauges, thermometers, flow meters and level gauges. This local instrumentation provides a visual indication. It is provided to aid in system commissioning and to de-bug system problems in the event of a failure or poor performance. Local instrumentation includes:

Pressure Gauges
RAW Pump Suction (2) Range is 0 to 60 psig
RAW Pump Discharge (2) Range is 0 to 100 psig
Intermediate Pump Suction (2) Range is 0 to 60 psig
Intermediate Pump Discharge (2) Range is 0 to 100 psig
RAW Expansion Tank (1) Range is 0 to 60 psig
Intermediate Expansion Tank (1) Range is 0 to 60 psig
DI-Bottle inlet header (1) Range is 0 to 60 psig
RAW Full Flow Filter Differential Pressure (1) Range is 0 to 10 psig
Intermediate Full Flow Filter Differential Pressure (1) Range is 0 to 10 psig
RAW Return Header (1) Range is 0 to 100 psig
Intermediate Return Header (1) Range is 0 to 100 psig

Temperature Gauges
Heat Exchangers Inlets and Outlets (8) Range is approximately 20 to 140 degree Fahrenheit.

Flow Gauges
Di-Bottle Flow (1) Range is 2 to 20 gpm

Level Gauges (Sight Glasses)
RAW Expansion Tank
Intermediate Expansion Tank